Research on the Net neutrality: the Case of Comcast Blocking

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***Abstract*—Net neutrality has caused a raging concern about Internet's open, accessible and innovative features. This paper summarizes the concept and origination of net neutrality, as well as the typical opinions of the proponents and opponents on net neutrality. It takes Comcast as an example, analyses the reason and measurement that Internet Service Providers (ISPs) enforced discriminatory access and blocking. We argue that peer-to-peer (P2P) softwares don't harm the whole quality of Internet; they just transfer the pressure from Content Providers (CPs) to ISPs. And the only loss caused by P2P protocols is that ISPs can't get premium revenues from CPs. We suggest that net neutrality should be preserved and regulated. Meanwhile, the government should stimulate the investment incentives of ISPs to encourage the deployment and optimization of new broadband network. If market forces can't achieve this goal, some market measures would be necessary.**

Keywords-Net neutrality; Regulation; P2P; Traffic

I. INTRODUCTION

Over the last two decades, the Internet and the World Wide Web have emerged as unprecedented open platforms for communication and innovation. Now, there is a raging debate around the question: how to ensure the Internet remains open, accessible and innovative, while at the same time encouraging the deployment of new broadband network. [1]The debate is mainly relevant to whether net neutrality is necessary to ensure that the Internet continues to function as an open, nondiscriminatory medium for exchanging ideas and innovation, and whether now is the time to take concrete steps (technical, legislative, or otherwise) to execute net neutrality.[6]

This paper summarizes the debate on net neutrality, and analyzes the essence of why Internet Service Providers block peer-to-peer applications.

II. WHAT IS NET NEUTRALITY?

There is no generally accepted definition about net neutrality. Tim Wu(2003) explained net neutrality as "the basic principle behind a network anti-discrimination regime is to give users the right to use non-harmful network attachments or applications, and give innovators the corresponding freedom to supply them."[3] Daniel J. Weitzner (2006) described four essential features of Internet Neutrality: 1. Non-discriminatory routing of packets; 2. User control and choice over service levels; 3. Ability to create and use new services and protocols without prior approval of network operators; 4. Non-discriminatory peering of backbone networks.[1] After an extensive debating about net neutrality, there had been some misinformation spread about, so Tim Berners Lee made some clarifications. He explained that "Net neutrality is this: If I pay to connect to the Net with a certain quality of service, and you pay to connect with that or greater quality of service, then we can communicate at that level. That's all. It's up to the ISPs to make sure they interoperate so that that happens. Net Neutrality is NOT asking for the internet for free. Net Neutrality is NOT saying that one shouldn't pay more money for high quality of service. We always have, and we always will. Net neutrality—the principle that Internet users should be able to access any Web content or use any applications, without restrictions or limitations from their Internet service provider (ISP). " [4]

In conclusion, a well-known concept of net neutrality is: Net neutrality (also network neutrality, Internet neutrality) is a principle proposed for user access networks participating in the Internet that advocates no restrictions on content, sites, or platforms, on the kinds of equipment that may be attached, and on the modes of communication allowed, as well as communication that is not unreasonably degraded by other traffic.[2]

III. ORIGINATION OF NET NEUTRALITY

The global debate over net neutrality initially originates from the United State of America. The US government takes the non-discrimination requirement as one of the most important governing principles when supervising the Internet in all relevant performance aspects, the same as the supervision of traditional telecommunication services such as telephone. In 2005, however, the Federal Communications Commission (FCC) changed the classification of Internet transmissions from "telecommunications services" to "information services." As a result, Internet service providers (ISPs) are no longer subject to non-discrimination restrictions. In fact, major telephone and cable operators, which together control about 98 percent of broadband service in the US (as of December 2005), expressed an interest to provide multitier Internet service and charge content providers (CPs) a premium price for preferential access to the broadband transmission service. In response, a coalition of content providers emerged in an effort to maintain the current status of non-discrimination regime. Their intensive lobbying effort led to the hot debate over net neutrality in Washington, along with initiatives to legislate a mandate to prevent creating a multitier Internet services. [7]

The debate has been triggered by the decision of the Federal Communications Commission's (FCC) allowing

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fixed network operator Verizon some degree of pricing freedom for its new investment on the improvement of broadband capacity. Verizon argued that it needed a better and more secure quality of service for time-critical applications such as live TV which otherwise would suffer from degradation. [7]

Around May 2007, one of the largest ISPs in the US, Comcast, began a program of discriminatory blocking of certain Internet communications protocols. The blocking focused on two peer-to-peer protocols BitTorrent and Gnutella,, and also included Lotus Notes enterprise collaboration software for a time. [6]

Many scholars did some research on the legal issues and abolition of net neutrality. And there are also a lot of investigations about economic issues of net neutrality. But the influence of peer-to-peer protocols on Internet congestion have not ever been investigated, which is important to explain the essence of ISPs blocking it, and significant to decide whether net neutrality is necessary.

IV. THE DEBATE ON NET NEUTRALITY

The core of the debate is the question of whether Internet Service Providers ought to be subject to a non-discrimination requirement. The pro neutrality camp has argued that neutrality must be legally mandated. Otherwise, the benefits of Internet would be lost. Those opposed to neutrality requirement argue that market forces will assure continued access to the Internet on reasonably neutral terms, and the legislating of this requirement will stifle investment in new broadband services. [1]

A. Proponents

Proponents of net neutrality include consumer advocates, online companies and some technology companies. Many major Internet application companies are advocates of neutrality, including Google, Yahoo!, Vonage, Ebay, Amazon, IAC/InterActiveCorp. Software giant Microsoft, along with many other companies, has also taken a stance in support of neutrality regulation. Individuals who support net neutrality include Moby, Tim Berners-Lee, Vinton Cerf, Lawrence Lessig, Robert W. McChesney, Steve Wozniak, Susan P. Crawford, and David Reed, and President Barack Obama. [2]

Net neutrality proponents advocate for legislation that would keep broadband service providers from controlling Internet content or gaining the ability to impose extra charges for heavy users of the Internet. [5]

Neutrality proponents claim that telecom companies seek to impose a tiered service model in order to control the pipeline and thereby remove competition, create artificial scarcity, and oblige subscribers to buy their otherwise uncompetitive services. Many proponents believe that net neutrality is primarily important as a preservation of current freedoms. [2]

B. Opponents

Opponents of net neutrality include large hardware companies and members of the cable and telecommunications industries. Net neutrality regulations are opposed by some famous Internet engineers, such as Professor David Farber and TCP inventor Bob Kahn. [2]

Net neutrality opponents argue that the existing rules enforced by the Federal Communications Commission (FCC) and other institutions make additional laws unnecessary, or could jeopardize service providers' First Amendment rights.[5]

Neutrality opponents characterize its regulations as "a solution in search of a problem", arguing that broadband service providers have no plans to block contents or degrade network performance. In spite of this claim, certain Internet service providers have intentionally slowed peer-to-peer (P2P) communications. Still, other companies have acted in contrast to these assertions of hands-off behavior and have begun to use deep packet inspection to discriminate against P2P, FTP and online games, instituting a cell-phone style billing system of overages, free-to-telecom "value added" services, and bundling. Critics of net neutrality also argue that data discrimination of some kinds, particularly to guarantee quality of service, is not problematic, but is actually highly desirable. Bob Kahn has called the term net neutrality a "slogan" and states that he opposes establishing it.[2]

V. BACKGROUND OF COMCAST BLOCKING

The interaction between Comcast's Internet access service network architecture and certain peer-to-peer protocols put pressure on Comcast's network that apparently Comcast didn't anticipate when designing its IP access service. Comcast uses Data Over Cable Service Interface Specifications (DOCSIS) to deliver Internet access service. Two properties of DOCSIS-provisioned services are relevant here. First, DOCSIS relies on a shared-media architecture to link groups of neighboring customers to a backbone-connected router. Second, Comcast's networks assume that customers will generate highly asymmetric traffic patterns, favoring download capacity over upload capacity.

Peer-to-peer protocols put pressure on both of these design properties. As neighboring customers share local network capacity, a small number of users consuming a large amount of bandwidth can degrade service quality in an entire neighborhood, especially if the Comcast network has shared bandwidth over many users. Under some circumstances, the BitTorrent protocol manifests the unusual property of increasing both downstream and upstream traffic from a user when he or she downloads a popular torrent (or file). This is because other peers in the BitTorrent network notice the popular file's availability and request their own copies from that user. According to Comcast, this unanticipated interaction between its network and the BitTorrent protocol compels Comcast to limit bandwidth to BitTorrent users to

provide adequate quality of service for others on the network.

As a general matter, ISPs take a variety of steps to manage traffic on their networks. TCP/IP implements basic congestion control techniques. ISPs block denial-of-service attacks and spam from malicious senders. However, the steps that Comcast has taken to deal with BitTorrent traffic differ from commonly accepted network management. Comcast limits what it considers to be offending peer-to-peer protocols using the Reset Packet Injection technique. The Reset (RST) message is a feature that the TCP protocol uses to enable a network endpoint to terminate a connection with another endpoint. Comcast injects RST packets between BitTorrent peers to slow down their communication and thereby reduce the amount of bandwidth used. In general, endpoints use this type of message to recover from certain error conditions. To prevent third parties from using the RST message to terminate a connection, the protocol requires the RST message to have certain information that only the communicating parties know. So, for Comcast to use the RST message, it must inspect the contents of the communication between the two peers to construct an RST packet that the endpoint will (incorrectly) consider valid. Experts on Internet standards agree that this RST injection technique is a misuse of basic Internet standards. Comcast's behavior set off a firestorm of debate, leading the FCC to hold a series of field hearings on the previously esoteric question of network management.[6]

VI. THE ESSENCE OF COMCAST BLOCKING

Although Comcast claimed that blocking was to ensure the adequate quality of service for others on the network, the reason of blocking is money. However, peer-to-peer protocols such as BitTorrent don't create any additional congestion in whole Internet. In fact, they just transfer the pressure of Content Providers to users, or more specifically to ISPs. Why would this happen? Without loss of generality, we assume that n users attempt to download the same video from a Content Provider, as shown in Figure 1.

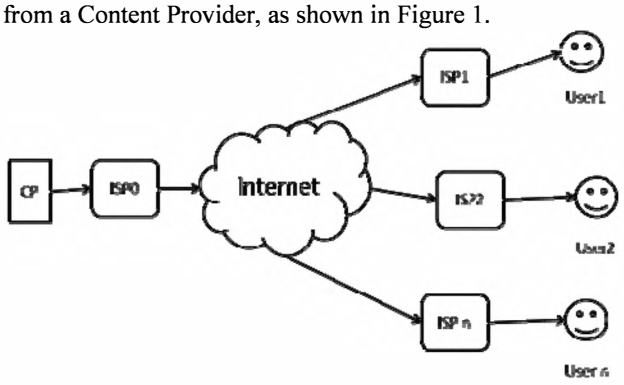

Figure1. n users download the same video from a Content Provider(CP)

Now, suppose the size of this video is S Mbytes, so every user occupies S Mbytes from respective ISP[1], so the traffic of ISPs indexed by i is:

$$t_i = \begin{cases} S\ \text{Mbytes}, & i \in (1, n); \\ nS\ \text{Mbytes}, & i = 0; \end{cases} \quad (1)$$

In the process of downloading the video, the server of this Content Provider has to upload nS Mbytes data. That is a large amount of upstream bandwidth. In order to satisfy the quality of service, Content Provider has to expand his bandwidth from ISP0. Meanwhile, except ISP0, other ISPs all transmit S Mbytes bandwidth, which is just a normal level, so there is no pressure to them. Therefore it seems every participant benefits from this model, at least no one losses.

However, there is a question about the reason why peer-to-peer applications appear. Because the Content Provider can't precisely estimate the exact number of users at a time, or at the peak time, they usually can't provide the satisfying quality of service to every user. Under this circumstance, many users prefer to download video files by BitTorrent which is the most famous peer-to-peer software. We consider another situation which assumes all users download the same video from/between users. A simplification of Figure 1 is illustrated in Figure 2, which dismisses the Content Provider, and adds the upload stream[2] of every user.

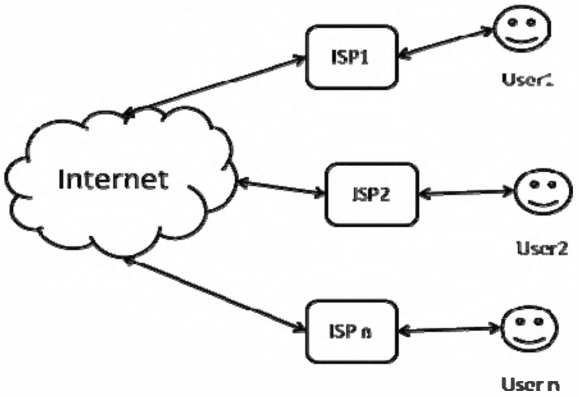

Figure2. Users use peer-to-peer applications

Assume that these n users want to download the same video. The difference is that the source the file isn't Content Providers but other users. Assume every user downloads this video successfully, and neglect the special route of the transferring of data, only consider the results, we can find that every user has S Mbytes downstream traffic, so the total downstream traffic is:

[1] Compare to the download bandwidth, the upload bandwidth during users downloading is far less, so we ignore the upload traffic; correspondingly, we can ignore the download traffic of CP, so the whole traffic of CP can approximately equals his upload bandwidth. And we assume this video is enough large that the control data during communication can be ignored, too.

[2] In this condition, assume every user has to provide the video to other users, so the upload traffic can't be ignored here.

$$T_d = nS \text{ Mbytes} \quad (2)$$[3]

Because users download videos from other users, the whole upstream traffic equals downstream traffic:

$$T_u = T_d = nS \text{ Mbytes} \quad (3)$$

Then, the average upstream traffic of each user is:

$$t_{ui} = T_u/n = S \text{ Mbytes} = t_{di}, \ i \in (1,n); \quad (4)$$

That is to say, every user uploads the same video during or after downloading it. So the bandwidth of every ISP is the sum of download and upload traffic of respective user:

$$t_i = t_{ui} + T_{di} = S + S = 2S \text{ Mbytes}, \ i \in (1,n); \quad (5)$$

Now, every ISP has to transmit twice traffic in this pattern compared with the one shown in Figure 1. One more important problem is that the upload bandwidth changes from almost zero to S Mbytes, which is a big burden for ISPs, especially in real case there isn't n ISPs to share the burden. This means that the situation of one ISP transmitting the nS Mbytes upload data could happens. As mentioned above, Comcast's network assumes that customers will generate highly asymmetric traffic patterns, favoring download capacity over upload capacity. So the upload capacity usually is much less than download capacity. The burden actually exists. At the same time, there is no such Content Provider here, so ISPs can't get premium revenue from this video transfer process. In other words, ISPs have to invest more to satisfy the quickly increasing need of uploading data with no gain. This analysis can explain why Comcast hates BitTorrent and other peer-to-peer applications so much.

On the other side, all the Internet Service Providers and Backbone Providers establish a platform on which users and Content Providers exchange their files and data packets. So the total traffic flowing through Internet is composed of two parts: the upstream and downstream. In both Figure 1 and Figure 2, the upstream traffic includes the upstream of CP and users; similarly, the downstream traffic includes the downstream of CP and users:

$$T_{u1} = T_u^{cp} + T_u^{u} = nS + 0 = nS \text{ Mbytes} \quad (6)$$

$$T_{d1} = T_d^{cp} + T_d^{u} = 0 + nS = nS \text{ Mbytes} \quad (7)$$

$$T_{u2} = T_u^{cp} + T_u^{u} = 0 + nS = nS \text{ Mbytes} \quad (8)$$

$$T_{d2} = T_d^{cp} + T_d^{u} = 0 + nS = nS \text{ Mbytes} \quad (9)$$

From above four equations, we can see that the total traffic is the same in Figure 1 and Figure 2, which means the peer-to-peer protocols don't generate additional traffic.

VII. CONCLUSIONS

We can come to a conclusion that peer-to-peer protocols don't degrade the quality of networks. It just hurts the Internet Service Providers' business benefit. And the business benefit should not be acquired by violating the neutrality of network; it would be adjusted by market forces. We suggest that net neutrality should be preserved. Furthermore, in order to stimulate the investment incentives of ISPs, some market measures could be carried out.

[3] We use the capital T stands for the whole traffic, the lowercase t stands for the specifical traffic of one party.

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